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Ontario Agricultural College and Experimental Farm.

RIPENING OF CHEESE IN COLD STORAGE.

By Prof. H. H. Dean, B.S.A., and Prof. R. Harcourt, B.S.A.

The following results have been obtained in continuing the experiments relating to the ripening of cheese in cold storage. Bulletin No. 121, published in June, 1902, gave the results of experiments conducted in 1901, which were reported as preliminary. The experiments of 1902 are a continuation and extension of the work.

Possibly no phase of the cheese industry has received so much attention in recent years, as the ripening of cheese at low temperatures. The season of 1902 was phenomenally cool, and Canadian cheese never enjoyed so good a reputation in British markets, as they did last season. This was partly due to the scarcity of cheese, but the cool season, no doubt, had a great deal to do with it; thus was demonstrated in a very forcible way the great value of low temperatures in the manufacture and transportation of Canadian cheese.

NATURE OF THE EXPERIMENTS.

The experiments of 1902 were divided into eight series or groups as follows:

1. Four cheese, marked A, B, C and E, weighing about thirty pounds each, were made from one vat of milk. A was placed, directly from the press, in an ice cold storage, which had an average temperature of 38.9. The lowest average monthly temperature was 37 degrees in April, the highest was 40.5 degrees in August. B was placed in an ordinary ripening room, which had an average temperature of 62 degrees, for one week, when it was moved to the ice cold storage. The highest monthly average of this ripening room was 66.2 degrees in July and the lowest 58.2 degrees in October. C was also placed in the ordinary ripening room and moved to the cold storage room at the end of two weeks. E was allowed to remain in the ripening room all the time. (The D cheese, which was moved to the cold storage at the end of three weeks in the experiments of 1901, was dropped from the tests in 1902.)

2. Five cheese, weighing about 30 pounds each, were made from one vat of milk and marked A, B, C, D, and E. The first four were placed at once, after taking them from the press, into an ice cold storage, while the fifth (E) was put in the ordinary ripening room, and remained there all the time. The A cheese remained in the cold storage during all the time of the experiments. B was moved to the ordinary ripening room, which had an average temperature of 62 degrees, at the end of one month. C was moved from the cold storage at the end of two months, and D at the end of three months.

The object of this experiment was to see what effect the changing of cheese, from a cold storage to an ordinary cool temperature, would have on the quality of the cheese.

3. The third series related to the effect on cheese of using an extra quantity of rennet (6 ounces per 1,000 pounds milk) in the milk as compared with the regular quantity of three and a third ounces per 1,000 pounds milk. The A cheese were placed directly in cold storage, the E in an ordinary ripening room.

while the B and C were moved from the ripening room to cold storage at th end of one and two weeks respectively, as in series 1.

4. Series 4 consisted of two sets of experiments. In both cases the chees were made by using a large quantity of rennet (6 ounces per 1,000 pound milk) cooking to 94 degrees instead of 98 degrees, and using one-half poun less (two pounds instead of two and one-half) salt per 100 pounds curd. One half the cheese were ripened in an ordinary ripening room and the other hal in an ice cold storage.

5. In the fifth series the curds were salted at the rate of two and a quarter pounds salt per 100 pounds curd as compared with two and three-quarter pounds salt per 100 pounds curd. Both lots were ripened in col storage

6. Five cheese, marked A, B, C, D, E, were made from one vat of milk. A and B were taken from the press to cold storage. A was put on a shelf and turned regularly, while B was placed in a cheese box and not turned. C, D, and E were put in the ripening room where E remained, but C and D were moved to the cold storage at the end of one week. C was placed on a shelf and turned regularly, while D was put in a cheese box and not turned.

7. This series related to the effect of formalin sprayed on the cheese and in the box to prevent mould.

8. Cheese were dipped in melted paraffine wax, which was at a temperature of about 180 degrees. Some of the cheese were placed in cold storage and some in an ordinary ripening room. A portion were dipped in the wax directly from the press, some at the end of one week, some at the end of two weeks and some at the end of three weeks, and the remainder were not coated with the paraffine.

RESULTS OF THE EXPERIMENTS.

1. Cheese Ripened in Cold Storage and the Ordinary Ripening Room.

From April 14th to September 15th, 1902, six lots of cheese were made—24 cheese in all. Six of these (the A's) were placed directly into cold storage from the press. The remaining eighteen were placed in the ripening room, six of which (B's) were removed to the cold storage at the end of a week, another six (C's) were moved into the cold storage at the end of two weeks, while the remaining six (E's) were allowed to ripen in the ordinary ro

The A cheese lost an average of 2.26 per cent. in weight at the en month. The B cheese lost an average of 2.90 per cent. in the same ti C lost 3.20 per cent., and the E cheese 4.21 per cent. in weight at th one month.

The cheese were all scored from one to four times. The first scoring of the E cheese was made in from six weeks to two months after they were made, while the cheese placed in cold storage were scored the first time when about three months old, and again at intervals of one month. This plan was followed in the scoring of all the cheese in the cold storage experiments.

Average Score of the Cheese. (All cheese were scored 10 for finish.)

Qualities.	Max.	A.	B.	C.	E.
Flavor	40	35.77	36.34	36.15	32.18
Closeness	15	14.16	13.93	13.84	13.65
Even Color	15	14.56	14.61	14.61	13.75
Texture	20	17.96	18.00	18.00	16.00
Finish.	10	10.00	10.00	10.00	10.00
Total	100	92.45	92.88	92.60	85.58

It will be noticed that there is very little difference in the quality of the cheese, whether put directly into cold storage or placed there after one or two weeks in an ordinary ripening room. However, we need to bear in mind that 1902 was an exceptionally cool season, and the cheese held in the regular ripening room for two weeks did not deteriorate so much as they would likely do in a hot summer. In 1901 those cheese put directly into cold storage from the press stood first in quality. If it is more convenient to do so we should judge that placing cheese in cold storage once a week, from the factory ripening (curing) room would be quite satisfactory.

The E cheese ripened in the ordinary room were inferior in quality as compared with those in cold storage. These results agree with those obtained in 1901.

2. Cheese moved from Cold Storage to Ripening Room.

It has been claimed that if dairy goods are held for some time in cold storage, and then brought into a moderately warm temperature, they would deteriorate very rapidly. To test this point, from April 17th to November 12th, six lots of cheese were made, having five cheese in each lot—thirty cheese altogether. Four cheese in each lot were taken to the cold storage from the press, while the fifth was placed in an ordinary room and remained there. One of the four (A) remained in the cold storage, while the other three were taken to the ripening room—B at the end of one month, C in two months, and D in three months.

The A cheese which remained in the cold storage lost 2.04 per cent. in weight at the end of a month, the B cheese lost 2.18 per cent., the C cheese 2.18, the D 1.87, and the E, in the ordinary ripening room lost 4.24 per cent. in weight in one month.

Average Score of the Cheese. (All cheese scored ten for finish.)

Qualities.	Max	A.	B.	C.	D.	E.
Flavor..	40	36.80	35.46	36.04	36.39	33.69
Closeness	15	14.36	13.88	13.83	13.72	13.80
Even Color	15	14.56	14.46	14.45	14.83	13.80
Texture	20	18.00	17.15	17.29	17.59	16.30
Finish..	10	10.00	10.00	10.00	10.00	10.00
Total	100	93.72	90.95	91.61	92.53	87.59

The cheese were scored about once a month during the season, after they became ripe enough to judge of their quality. The final scorings were made in April, 1903, hence there has been every opportunity to judge of the effects of moving cheese from cold storage to ordinary temperatures. The scorings show that the A cheese, which remained in the cold storage during the whole ripening period were first in quality, and the cheese range in order of merit from the date of moving them—the best cheese being those which remained in cold storage longest, although there was no marked deterioration in those moved to a warmer temperature. All the cheese which were ripened in cold storage from one to three months were better in quality than those in the ordinary room.

3. Cheese Made with Extra Rennet and Ripened in Cold Storage.

Eight lots of cheese, having four in each lot, were made between April 21st and September 8th. Each lot was made by using rennet at the rate of six ounces per 1,000 pounds milk instead of the usual quantity (three and a third ounces).

The A cheese were placed directly from the press in cold storage at an average temperature of 38.9 degrees. The B and C cheese were moved into cold storage at the end of one week and two weeks, while E remained in the ordinary room.

The percentage loss in weight in one month was respectively 2.37, 2.75, 3.20, and 3.86, on cheese weighing about 30 pounds each.

The average score of the cheese was as follows:

Average Score of the Cheese.

Qualities.	Max.	A.	B.	C.	E.
Flavor	40	36.70	26.70	36.20	33.30
Closeness	15	14.30	11.25	13.85	13.50
Even Color	15	14.80	14.67	14.60	14.60
Texture	20	18.65	18.27	18.10	17.70
Finish	10	10.00	10.00	10.00	10.00
Total	100	94.45	93.89	92.75	89.10

The scorings show that the cheese placed directly in cold storage were best in quality, and the other two lots range in quality according to the time of placing in cold storage—those put in at the end of a week being first and those at the end of two weeks being second, while those ripened in the ordinary room are poorest. In series one there was very little difference in the first three lots whether placed at once into cold storage, or whether placed at the end of one or two weeks. In this series with the larger quantity of rennet, those placed directly into cold storage scored considerably higher, and they are also higher in scoring than the average of either series 1 or 2.

4. Cheese Made with Extra Rennet, Cooked to 94 Degrees and Salted Lightly.

Twelve lots of cheese were made from May 20th to August 21st from milk containing an average of 3.71 per cent. fat. One-half the cheese were made in the usual way, and the other half were made by using from two and a half to six ounces of rennet per 1,000 pounds milk; the curds were cooked to 94 degrees, and they were salted one-half pound of salt less per 100 pounds curd. Both lots were ripened in an ordinary ripening room at an average temperature of 62 degrees, and a humidity of 80.2 per cent.

The other set of experiments belonging to this series, consisted of fourteen lots of cheese made between April 22nd and August 15th from milk averaging 3.73 per cent. of fat. They were made similar to the first set, i.e., one-half in the usual way and the other half by using more rennet, cooking at 94 degrees and using one-half pound less salt, but both lots were ripened in cold storage at an average temperature of 38.9 degrees, and 90 per cent. humidity.

Average Score of Cheese in Series 4.

Qualities.	Max.	Ripened in ordinary room.		Ripened in cold storage.	
		Cheese made with extra rennet, etc.	Cheese made in ordinary way.	Cheese made with extra rennet, etc.	Cheese made in ordinary way.
Flavor	40	34.50	34.56	35.76	36.29
Closeness	15	13.66	13.50	14.17	14.23
Even color	15	13.82	13.82	14.47	14.58
Texture	20	16.66	16.66	17.00	17.88
Finish	10	10.00	10.00	10.00	10.00
Total	100	88.64	88.48	91.40	92.98

The green cheese made by using an extra amount of rennet, cooking to a lower temperature and using less salt, produced an increase of 1.1 per cent. of ripened cheese when ripened in the ordinary room, and an increase of 2.4 per cent. when ripened in cold storage. The scorings show very little difference in the average quality of the cheese ripened in the ordinary room, which is different from the results obtained in previous years when such cheese were "acidy" and of inferior quality. The cool season may account for the difference in the results for 1902.

The other lots of cheese made from extra rennet, etc., and those made in the usual way, but ripened in the cold storage, were both superior in quality as shown by the scorings. However, the cheese made in the usual way scored somewhat higher, and we are not prepared to recommend cheesemakers to leave more moisture in the curds to increase the yeild of cheese ripened in cold storage, until we have further data. It is quite possible to increase the yield of cheese from one to two and a half per cent., but it would appear to [illegible] at the expense of quality, so far as we have light at present.

Further experiments made in 1903 indicate that the quality of the cheese was not injured by an increase of one to two per cent. moisture in the cheese ripened in mechanical cold storage, though it might be injured in an ice cold storage.

5. Ordinary vs. Light-Salted Cheese Ripened in Cold Storage.

In series 5 the object was to note the effect of using one-half pound less salt per 100 pounds curd, when cheese were ripened in cold storage. Between August 16th and October 11th, 1902, twelve lots of cheese were made. At the time of salting, the curds were equally divided, and six were salted at the rate of two and a quarter pounds of salt per 100 pounds curd, while the other six lots were salted at the rate of two and three-quarter pounds salt per 100 pounds curd. The cheese were made from milk averaging 3.85 per cent. fat, and averaged about 31 pounds in weight. There was a slight increase (about one-half a pound on 31 pounds. cheese) in the yield of the cheese by salting two and a quarter pounds per 100 pounds curd. The average total score was 93.78 for the cheese lightly salted and 94.46 for those salted in the usual way. There was a slight decrease in the yield of the cheese by the heavier salting and an improvement in the quality.

6. Boxing Green Cheese and Ripening in Cold Storage.

This series was undertaken to obtain further data upon the practicability of placing cheese in a box directly from the press, or after remaining one week in an ordinary ripening room, instead of placing the cheese on shelves and turning them daily, which involves a great deal of labor.

Between July 2nd and November 5th, 1902, twenty-five cheese were made. Five were marked A, and were put directly from the press on a shelf in the cold storage and turned frequently. Five were marked B and also taken directly from the press to cold storage, but were put into boxes without turning. C and D were taken to the cold storage, after remaining a week in the ordinary ripening room, when the C's were placed on a shelf and turned, while the D's were put into a box and not turned. The E's remained in the ordinary ripening room.

The A's lost an average of 2.35 per cent. in weight during one month, while ripening, the B's 1.74, the C's 2.69, the D's 2.36 and the E's 4.67 per cent.

Average Score of the Cheese in Series 6.

Qualities.	Max.	A.	B.	C.	D.	E.
Flavor	40	37.05	37.65	37.40	37.50	35.28
Closeness...............	15	14.50	14.20	14.50	14.35	13.85
Even color.............	15	14.40	14.30	14.35	14.30	14.14
Texture	20	18.10	18.40	18.20	18.10	16.71
Finish	10	10.00	10.00	10.00	10.00	10.10
Total	100	94.05	94.55	94.45	94.25	89.98

The scorings show very little difference in the quality of the four lots of cheese. The B cheese which were put in boxes in cold storage directly from the hoops have the highest average score, while those ripened in the ordinary room are the lowest in the series as in all the others. The results indicate very forcibly that cheese may be put into a dry, clean, cheese box directly from the press, or after being one week in an ordinary ripening room, and then be put in cold storage at an average temperature of 38 to 40 degrees, and 90 per cent. humidity with very satisfactory results. These were the best cheese made during the season, and all those who judged them pronounced them "finest" goods. The large amount of mould which collected on the outside of the cheese in the box was the chief drawback. To overcome this a series of experiments with formalin were made.

7. *Formalin Sprayed on the Cheese to Prevent Mould.*

Cheese made April 22nd, 29th, May 6th and May 27th, which had as nearly as possible an equal quantity of mould on each, were put into boxes. One-half were sprayed with formalin, and the other were not sprayed. When examined on August 26th those not sprayed were found to be very mouldy, while those which had been sprayed on the ends of the cheese and very lightly in the box, and on the scale boards were quite free from mould. Other cheese put directly from the press into boxes in cold storage and sprayed with formalin were equally free from mould. This plan would seem to be a preventive of mould, but owing to the strong nature of the formalin, not many cheese could be treated at one time by the same person, and the expense would be considerable with a large number of cheese. Some better remedy will doubtless be found.

8. *Paraffining Cheese.*

Experiments were continued during 1902 with dipping cheese into paraffine wax at a temperature of about 180 degrees. The cheese were dipped at stages, directly from the press, at the end of one week, two weeks and three weeks.

The best results, in appearance, were got by dipping the cheese in hot wax about one week after they were made, and then placing the cheese in cold storage. For cheese ripened in an ordinary room, we can see no particular advantage in paraffining cheese. It tends to prevent the growth of mould, and prevents loss of weight while ripening. Recent reports from England say that the cheese which have been paraffined have not been well received on the markets of Great Britain. The chief advantage seems to be to prevent loss of weight while the cheese are held. It will probably pay the speculator to have the cheese coated, but it is a question whether it will pay the average factoryman to dip his cheese in paraffine wax at the present time.

Average Score of the Cheese in Paraffining Experiments.

Cheese.		Average flavor.	Average closeness.	Average color.	Average texture.	Average total.
When made.	Paraffined.	Max. 40.	Max. 15.	Max. 15.	Max. 20.	Max. 100.
Aug. 18........	From press.....	36.94	13.94	13.61	17.44	91.94
Sept. 1 and Sept. 22. Ripened in cold storage.	Not paraffined..	37.00	13.94	13.77	17.44	92.16
Oct. 6 and 13 ...	From press.....	35.75	13.25	13.87	17.12	90.00
	1 week.......	36.37	13.00	13.50	17.12	90.00
	2 weeks.......	36 87	13.50	13.62	17 62	91.62
	3 weeks......	37 25	13.62	13.87	17.37	92.12
Ripened in ordinary room. ...	Not paraffined..	37.00	13.75	14.00	17.62	92.37

The cheese made during August and September were scored on November 22nd, 1902, and January 1 and April 14th 1903, by Mr. G. H. Barr, as were also those made in October. The cheese not paraffined averaged slightly higher in quality, when full points were given for finish as in the other series. Taking appearance or finish into account, they scored lower. The average of three scorings for appearance on three lots of paraffined cheese made during August and September ripened in cold storage was 6.33 out of a possible ten, while the lots not paraffined averaged 3.55 points.

The October lots not paraffined also scored slightly higher when giving full points for finish. Taking appearance into account they scored an average of 6.5 points out of a possible ten. Those dipped at the end of three weeks scored 7.5, those paraffined in two weeks 8.0, those in one week scored 9.25, and those dipped in paraffine wax directly from the press scored an average of 8.75.

The chief gain was in the saving of shrinkage. The paraffined cheese lost no more than the weight of the wax which adheres to the cheese. Those dipped in one week lost .78 per cent., in two weeks 1.57 per cent., three weeks 2.36 per cent., and those not coated lost 3.16 per cent. in one month. The cheese weighed an average of about 30 pounds each.

ACIDITY OF THE MILK AND CURD.

The acidity of the milk at the time of adding the rennet varied from .2 on June 9th to .23 on July 21st and September 8th. It averaged .216 for the sea-

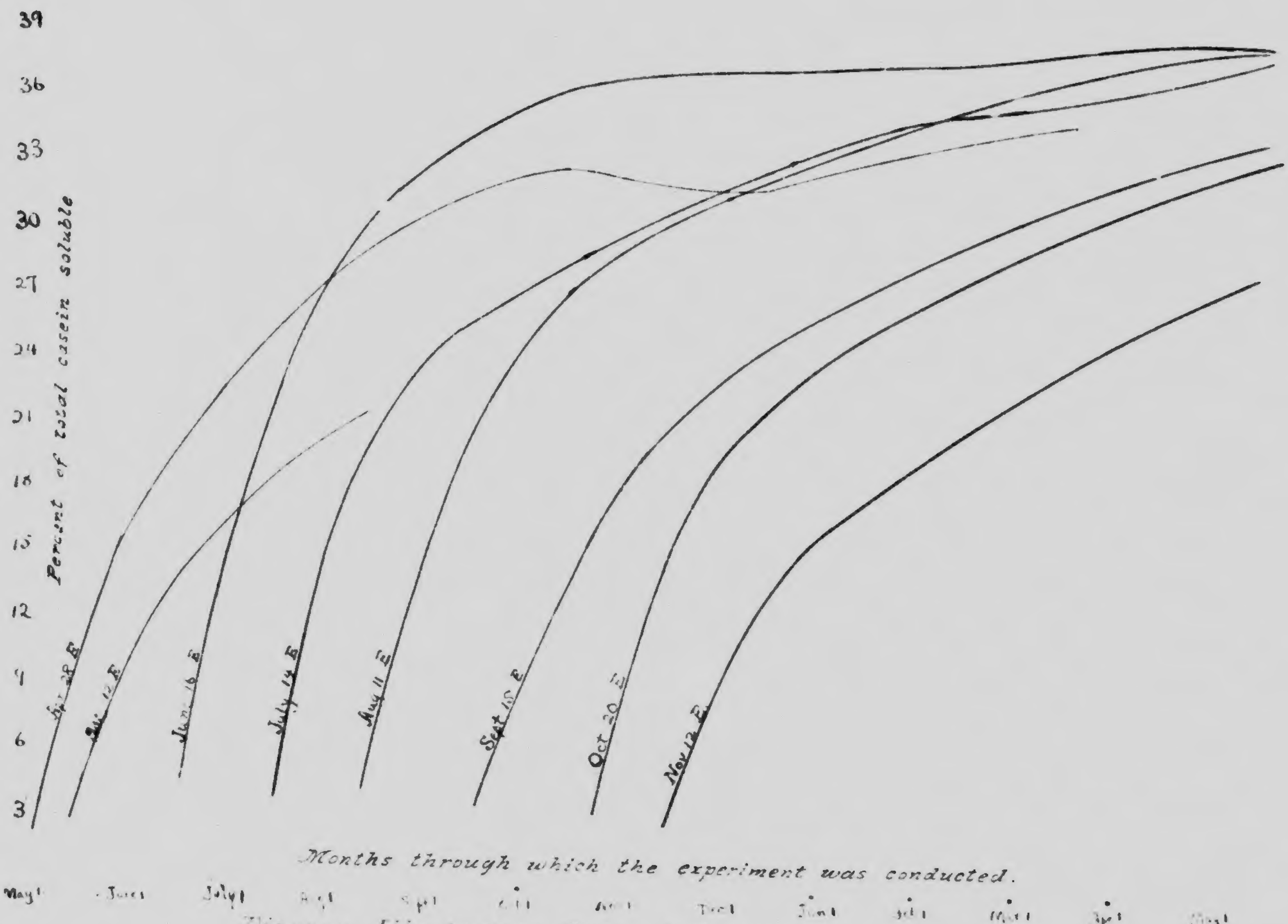

Diagram Illustrating Rate of Ripening at 60° to 65° F which the experiment was conducted.

May 1 June 1 July 1 Aug 1 Sept 1 Oct 1 Nov 1 Dec 1 Jan 1 Feb 1 Mar 1 Apr 1 May 1

Diagram Illustrating Rate of Ripening at 60° to 65° F.

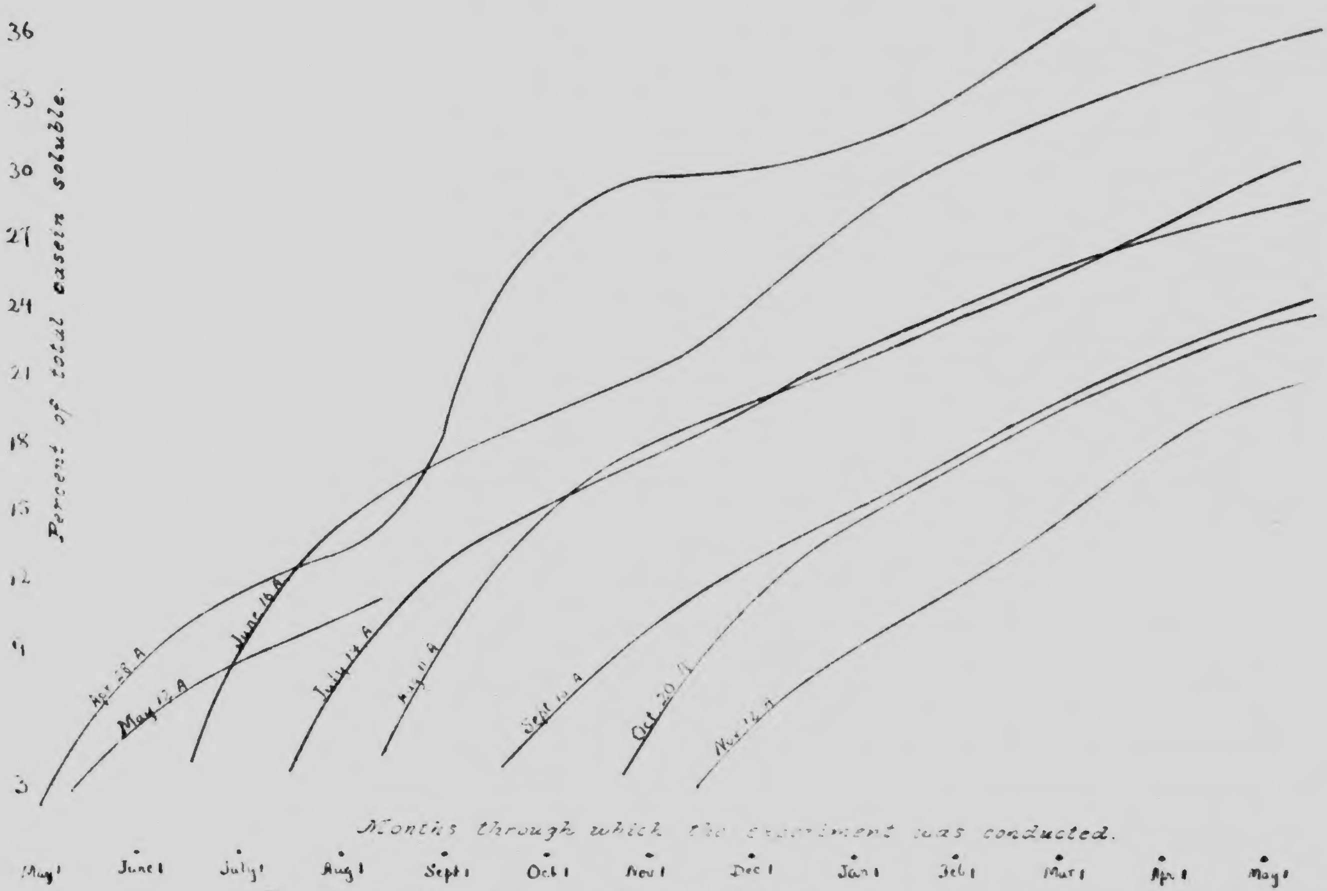

Diagram Illustrating Rate of Ripening at 40° F.

son. At dipping, the curd ranged from .18 to .23 and averaged .198 for the season. When the curds were milled the acidity varied from .69 to .9 and averaged .806. At the time of salting, the acidity varied from .85 to 1.14 and averaged 1.005 for the season.

In our cheese work at the Dairy department of the College, we have practically discarded the rennet and hot iron tests, as the acidimeter is more convenient, less wasteful of material, and much more accurate in its results.

WHITE SPECKS IN CHEESE.

No white specks were noticed in the cheese ripened in cold storage in 1902. The only explanation we can offer is that the cheese were not allowed to go below freezing point in the winter of 1902 and 1903, whereas in the winter of 1901 and 1902 the cheese were below freezing point, and the white specks were quite pronounced in the cheese.

The general conclusions of Drs. Babcock and Russell of Wisconsin on this question are:

"The chief factors determining the formation of white specks in cheddar cheese seems to be that of temperature and salt. Low temperatures favor very much the production of these specks. Rarely do they appear at 60 degrees Fah., except where other conditions are peculiarly favorable for their production."

"The addition of salt tends to prevent their formation under all conditions. Also they are not so apparent when increased quantities of rennet are used. They are especially abundant in skim cheese, but do not appear in very rich cheese even at low temperatures. In sweet curd cheese no specks were found at any temperature."

THE EFFECT OF TEMPERATURE ON THE RATE OF RIPENING OF CHEESE.

There is every reason to believe that the ripening of cheese depends on the growth and chemical changes produced by ferments. Just what are the best conditions under which these ferments work is not definitely known, nor are the chemical changes that take place fully understood. It has been proved, however, that cheese will ripen more slowly, and will develop a milder, cleaner flavor and better texture at a temperature of 40 degrees Fah. than at 60 degrees Fah. All the chemical changes which take place within the cheese during the ripening process have not been studied out; but it is known that one of the most important is the changing of the insoluble casein into soluble compounds. These changes apparently take place much more slowly, especially in the early stages of ripening, at the lower temperature. In order to study the amount of casein rendered soluble and the comparative rate at which these changes take place under the two different conditions of ripening, a large number of analyses of cheese were made from month to month in 1901 and again in 1902. The cheese used in this work were marked A and E in series 1 of this bulletin, and cheese made and ripened under similar conditions in 1902, also marked A and E*. In both year's experiments the A cheese were placed at once in cold storage, the average temperature of which for the season was 38.9 degrees Fah., and E in ordinary ripening room, where the average temperature was 62 degrees Fah. An endeavor was made to determine the total amount of nitrogenous matter, or casein, the amount of casein soluble in water, and the amount of ammonia, which is the end product in the decomposition of the casein, in A and E cheese for each month from April to November. With the exception of September, a monthly analysis was also made of each cheese made in 1902 from date of making to May, 1903. The analyses were not made so regularly in 1901, but enough was done to show the amount of casein rendered soluble monthly during a period of eleven months.

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*See Bulletin 121, Ontario Agricultural College. Ripening of Cheese in Cold Storage Compared with Ripening in Ordinary Curing Room.

NOTES ON METHODS OF ANALYSIS.

Sampling. In taking the sample for analysis, two plugs were drawn from opposite sides of the cheese by means of an ordinary cheese tryer and bottled at once. The sample was then chopped up fine inside the bottle with a thin spatula, well mixed, and tightly corked up. From this portions were taken for analysis.

Total Nitrogenous Matter, (principally casein). The nitrogen as determined by the Kjeldahl process, was multiplied by 6.25 to obtain nitrogenous matters.

Water Soluble Nitrogenous Water. Ten grams of cheese were ground in a porcelain mortar with sharp clean sand, transferred to a flask, treated with from 75 to 100 cc. of cold distilled water, and warmed in a water bath to 60 to 65 degrees C. as soon as possible. After reaching this temperature and after thorough stirring the liquid was poured on a pad of cotton wool in a glass funnel and filtered into a 500 cc. flask. Another portion of water at about 60 degrees C. was then poured on the sand and cheese, and the flask containing them replaced in a water bath at 60 to 65 degrees C. This operation was repeated six or seven times, with frequent stirrings, the water remaining in contact with the cheese from 15 to 30 minutes. Each extraction occupied from two to three hours. The cheese extract thus obtained was cooled and made up to a volume of 500 cc., and then filtered under pressure through a thick pad of asbestos. The nitrogenous matter soluble in water was then obtained by determining the nitrogen in an aliquot portion of the extract by the Kjeldahl process, and multiplying it by the factor 6.25.

Ammonia was determined in the original cheese by grinding a suitable quantity (usually 10 grams) with cold water in a porcelain mortar, transferring to a distillation flask, making alkaline with magnesium oxide (MgO) and distilling off the ammonia.

It is not, strictly speaking, correct to use the term "casein" when the total nitrogenous matter is meant; yet, as casein is the principal nitrogenous constituent of new cheese and the one best known to dairymen, it will be used in that sense in the discussion of results hereafter given.

RATE AT WHICH CASEIN IS CHANGED TO SOLUBLE COMPOUNDS.

The following table gives the average percentage of total casein in A and E cheese found soluble in water at the end of one, two, three, and up to eleven months. The figures do not represent the rate at which the casein in any one pair of cheese became soluble; but the average of all cheese for the season when one, two, three, etc., months old. The percentage of total casein changed to ammonia for the same periods is also given. These figures, therefore, represent the averages obtained from cheese one or more months from date of making at all seasons of the cheese-making year.

The average percentage amount of total casein changed to soluble and ammonium compounds per month for 1901 and 1902.

Age of Cheese.	1901.				1902.			
	A.		E.		A.		E.	
	Per cent. of total casein changed		Per cent. of total casein changed		Per cent. of total casein changed		Per cent. of total casein changed	
	to soluble compounds	to ammonium compounds.	to soluble compounds	to ammonium compounds.	to soluble compounds	to ammonium compounds.	to soluble compounds	to ammonium compounds.
1 month.	9.7	....	17.7	.75	9.9	....	17.6	1.5
2 months	14.6	....	25 3	1.2	12.6	....	23.1	2.2
3 "	15.4	.5	26.3	....	15.1	1.5	24.7	2.3
4 "	16.9	....	28.2	....	17.8	1.5	29.8	3.1
5 "	18.2	.7	30.0	1.8	21.3	2.0	32 1	3.5
6 "	20.6	.8	32.5	2.5	22.4	2.1	33.1	3.4
7 "	....	....	....	....	24.8	2.7	34.9	3.9
8 "	26.9	2.3	37.5	3 5	27.8	2 6	36.8	4.2
9 "	26.5	1.5	37.1	4 2	29.1	2.8	38.1	4.4
10 "	28.2	2.8	38.3	4.5	29.0	3.0	38.7	4.6
11 "	32.9	2.8	40.6	5.0	....	....	....	....
Average monthly gain after 1 month.	2.26	....	2.33	....	2.13	....	2.34	....
Average monthly gain after 2 months.	1.97	....	1.74	....	2.06	....	1 95	....

Two points are particularly noticeable in this table. First, the E cheese contained at any given time more soluble compounds than the A cheese; and, second, the E's made most of their gain in solubility over the A's during the first month. Looking at the average monthly increases in solubility from the time the cheese were one month old given at the bottom of the table, it will be seen that in both years' work the E cheese gained a little faster than the A's; but that taking an average of the increases from two months on, the E's did not gain so rapidly as the A's. The casein of the E cheese was broken down a little more quickly during the second month than that of the A's; yet it is evident that the cheese ripened at the higher temperature made the most of their gain over those in cold storage during the first month and that from that time on they ripened fairly evenly. If we measure the ripeness of the cheese by the breaking down of the insoluble casein as shown by the percentage amount soluble the cheese kept at a temperature of from 60 to 65 degrees Fah. are as ripe at the end of one month as those kept at about 40 degrees Fah. are at the end of four months.

It appears as though the amount of ammonium compounds formed is somewhat proportional to the casein rendered soluble.

The percentage amount of total casein soluble in the different pairs of cheese at the time of the monthly analysis is given in the following table. The first column gives the date of making and the succeeding ones the conditions of the casein immediately on taking from the press and at one, two, and up to eleven months from that time.

Percentage amount of total casein soluble in water at stated intervals in cheese made in 1902.

Date of Manufacture.	1 day.	Number of months from date of making.										
		1	2	3	4	5	6	7	8	9	10	11
April A..	......	8.0	11.4	.....	15.4*	......	31.2	28.1	31.1	31.6	36.7	....
28th E..	...	15.5	22.8	.....	29.2	......	33.0	30.7	32.3	33.8	37.3	....
May A..	2.7	7.4	9.2	11.2	Disca	rded o	n acco	unt of	devel	opme	nt of	a
12th E..	2.7	14.1	17.9	21.8		bad	flavor.					
June A..	4.0	13.5	16.3	......	21.6	21.6*	29.2	28.5	32.4	34.1	34.8	36.6
16th E..	4.0	22.7	31.8	...	36.5	37.9	37.1	37.2	38.9	58.1	40.5	39.5
July A..	3.7	12.1	....	16.5	18.1	21.9	22.3	26.2	26.4	27.7	29.5	....
14th E..	3.7	22.1	.....	28.9	30.1	33.7	34.7	35.8	36.7	37.0	38.7	....
Aug. A..	4.3	...	17.4	18.5	20.6	23.1	25.3	24.8	31.1	30.5	...	....
11th E..	4.3	......	28.8	29.7	32.5	34.1	37.9	35.8	38.8	39.2	.....	....
Sept. A..	....	9.7	11.1	16.1	15.3	20.1	21.7	23.5	24.6	.....	.....	....
15th E.	.....	16.6	22.0	21.1	28.2	30.9	32.1	33.7	35.0	.....	.....	....
Oct. A..	3.6	10.5	13.7	15.7	19.6	20.3	24.3	22.9	.....	.....	.....	....
20th E..	3.6	18.0	21.3	25.5	29.2	29.7	32.2	34.3	....	.....	.....	....
Nov. A..	.....	8.2	9.3	12.5	16.2	20.5	18.5	...	...	.....	.....	....
12th E..	.....	14.0	17.2	21.5	22.6	26.2	28.8	.....	....	......	.....	....

* A and E cheese reversed at this point.

Here again it is evident that the casein of both cheese of each month was changed to a soluble form faster during the first month than during succeeding months and that the casein of E cheese became soluble much more rapidly than A. This is also true, although the development was slower, in the second month; but from that time on the cold storage cheese seemed to ripen as rapidly as those at the higher temperature. As the most rapid gain of the E's over A's is not so great during the second month, it is possible that the first six weeks covers the time during which the former ripens faster than the latter.

Another point worthy of notice in this table is that the cheese made in June, July, and August contained a larger amount of soluble compounds at the time of taking from the press than those made in the spring and fall. They also gained in solubility, or ripened, much faster than those made in other months. This applies to those kept in cold storage as well as to those kept in the ordinary ripening room, and is doubtless due to the difference in the condition of the milk, or its germ content, at that season of the year; for, the milk was brought to the same degree of acidity before adding the rennet and treated the same throughout the after process in all the different experiments.

When the April cheese were four months old, or in August, the A and E cheese were reversed; that is, A was taken out of cold storage and placed in the ordinary ripening room at a temperature of 60 to 65 degrees Fah., while E was taken from this latter room and placed in cold storage. Notice the very rapid gain in the amount of casein soluble from the fourth to the sixth months in A, while the rate of change in E became slower. The June cheese were reversed in November and the same changs are noticeable. Why the results should be lower in some instances than they were in the preceding month, as, for example, the sixth and seventh months of April cheese, cannot be explained, unless it is due to errors in sampling. As cheese is a mixture of substances, no assurance can be given that the two plugs taken as a sample always accurately represented the whole cheese. Yet larger samples could not very well be taken when the analyses were to be continued for a number of months. At the same time, the monthly analyses probably give results which fairly well represent the changes in the solubility taking place during the ripening process.

The curved lines in the accompanying diagrams graphically represent the rate at which casein changed to soluble compounds in the cold storage cheese as compared with those ripened at the higher temperature. Notice how much more perpendicular the first part of the lines representing E cheese are than those representing A cheese. It will be remembered that April cheese were reversed in August; notice the abrupt upward curve of the line representing A cheese at this point. June cheese were reversed in November, but the upward curve following the change is not so pronounced as in the preceding case. Possibly this is due to the casein being at a more advanced stage of decomposition when the cheese were changed. Another noticeable point is the similarity in the rate of ripening of July and August cheese under A and E conditions. The same may be said of September and October.

The quality of the cheese under the two methods of ripening has been dealt with on page 2 of this bulletin; but for purpose of comparison, the total scores and the time at which they were made are given in the following table:

Total scores at several different dates.

Date of Manufacture.	Number of months from date of making.										
	1	2	3	4	5	6	7	8	9	10	11
April A			89 0	.... *				85.6			
28th E			85.0	84.0		89.0		83.0			
May A		83.0	77 0		77.0						
12th E		79.0									
June A				93.0	94.0*	95.0				87.0	89.0
16th E		85.0		91.0		87.0					85.0
July A			95.0		96.0		92.0			95.0	
14th E			92.0		89.0				85.5	86.0	
Aug. A						92.0		93.5	99.0		
11th E		90.0		85.0					84.0		
Sept. A					91.5		96.0	95.0			
15th E		91.0	84.0				81.0	73.0			
Oct. A				92.5		96.0	98.0				
20th E	89.0	86.0				90.0	91.0				
Nov. A			96.0		93.5	96.0					
12th E	89.0				88.0	88.0					

* A and E cheese were reversed at this point.

Unfortunately, the scoring was not followed regularly on the April and June cheese after the A's and E's were reversed. The score indicates that the cheese kept in cold storage have a much longer commercial life than those ripened at a higher temperature.

The Influence of Salt on Cheese.

In some investigation work done by Mr. H. Rive, B.S.A., in connection with his graduation thesis, the cheese made as outlined in series 5 of this bulletin, were analyzed. From the results he obtained, the percentage of salt, moisture, and total casein soluble, as affected by the two quantities of salt used, are selected. The twelve cheese were examined twice—once when they were two, three, and four months old, and again when five, six, and seven months old. The results reported under two and five, three and six, four and seven months are from the same cheese; and as there were two pairs of cheese each month, each result is an average obtained from two cheese. The following are the results:

Effect of different quantities of salt on the amount of moisture and salt retained, and on the rate of decomposition of the casein of cheese.

Age of cheese.	Per cent. of salt retained when curd was salted at the rate of		Per cent. of water retained when curd was salted at the rate of		Per cent. amount of total casein changed soluble compounds, salted.	
	2.25 lbs. per 100 lbs. curd.	2.75 lbs. per 100 lbs. curd.	2.25 lbs. per 100 lbs. curd.	2.75 lbs. per 100 lbs. curd.	2.25 lbs. per 100 lbs. curd.	2.75 lbs. per 100 lbs. curd.
2	....	....	....	....	12.5	11.6
3	....	....	....	....	22.2	20.3
4	....	....	....	....	21.6	20.2
5	1.50	1.64	33.97	33.19	23.2	21.9
6	1.72	1.92	34.01	32.88	27.5	26.5
7	1.75	1.98	33.83	33.25	26.0 *	24.0 *
Average....	1.66	1.84	33.91	32.10	....	....

* From one cheese only.

According to these results, one-half pound more salt decreased the amount of moisture by nearly one per cent. It also retarded the rate at which casein was changed to soluble compounds. The amount of salt retained in ripe cheese is not in proportion to the quantity added. If the heavier salted cheese retained salt at the same rate as the lighter salted ones, they would have contained 2.03 per cent. instead of 1.84. Two years ago Dr. Van Slyke, New York State Experiment Station, Geneva, drew attention to results similar to those just given*. His experiments were conducted with cheese ripened at 70 degrees Fah., while those used in this experiment were ripened at a temperature of 40 degrees Fah.

Conclusions.

1. The cheese ripened in cold storage at a temperature of about 38 degrees were much superior in quality to those ripened in an ordinary ripening room at a temperature of about 62 degrees. The chief improvement is in flavor and texture. The cheese ripened in cold storage have a mild, clean flavor and silky texture, while those ripened in the usual way were more liable to be "off flavor" and "mealy" in texture, especially when from three to six months old, at which time those ripened in cold storage are beginning to get in good condition for eating. These results correspond with those obtained in 1901.

2. If we measure the ripeness of the cheese by the amount of casein changed to compounds soluble in water, the cheese kept at the higher temperature were as ripe at the end of one month as those kept at a lower temperature were at the end of four months.

3. The cheese placed in the ordinary ripening room ripened much faster during the first month, a little faster during the second month, but more slowly during the succeeding months than those placed in cold storage.

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*Report of Ontario Dairymen's Association for 1901.

4. The cheese made in the months of June, July, and August ripened faster, both in the ordinary ripening room and in cold storage, than those made in the spring and fall months.

5. The cheese which were ripened in cold storage for periods of one to three months and then moved to an ordinary room, did not deteriorate rapidly after moving, but those allowed to remain in cold storage for the longest period were the best in quality. So far as those experiments indicate there is no risk in moving cheese, which has been ripened in cold storage, to an ordinary temperature for a reasonable length of time.

6. When cheese were removed from cold storage and placed in the ordinary ripening room the rate at which casein was decomposed increased, while, when the change was made in the opposite direction, apparently the reverse was true.

7. An extra quantity of rennet used in making some of the cheese placed in cold storage appeared to improve the quality as compared with cheese made in the other series, although no direct experiments on this point were made in 1902. The results also indicate that if a large quantity of rennet be used, the cheese should be placed in cold storage soon after being made in order to obtain the best results.

8. An increased yield of cheese equal to one or two per cent. may be obtained by using an extra quantity of rennet, and by cooking to 94 degrees, and by salting lightly, but the quality of the cheese made in this way in 1902 were not so good as those of 1901. At present we do not recommend cheese makers to try to leave more moisture than usual in the curd where cheese are to be placed in ice cold storage, though later experiments indicate that it may be all right for cheese ripened in mechanical cold storage.

9. From the results obtained during the past two years it would appear to be quite feasible to place cheese boxes in cold storage either directly from the press or after remaining a week on the shelves. This plan means a great saving in labor, and a saving of shelf room. The chief drawback is the growth of the mould on the cheese. This can be overcome to a large extent by spraying formalin on the cheese and in the boxes. The boxes should be clean and dry.

10. Dipping the cheese in paraffine wax at a temperature of 180 degrees makes a light coating over them, which prevents loss of weight while ripening or when held in cold storage. It also tends to prevent the growth of mould, and to some extent improves the appearance of the cheese, especially when placed in cold storage. So far as our work has gone we are not prepared to recommend the general paraffining of cheese to the ordinary factoryman. If the cheese are acceptable to British buyers, it would seem that the speculator in cheese is the person who would receive most profit from the process.

11. No "white specks" were noticed in the cold storage cheese of 1902, which we attribute to the fact that the cheese were not allowed to go below 32 degrees Fah. as they did in 1901, when the "white specks" were observed.

12. The amount of salt retained in cheese was not in proportion to the amount added.

13. When curd was salted at the rate of 2.75 pounds of salt per 100 pounds of curd, there was less water in the cheese, and the rate at which casein was changed was slower than when 2.25 pounds of salt were used.

14. Cheese ripened at a low temperature ripened more slowly during the first month or six weeks than those kept at a higher temperature; but after this period one ripens as fast as the other.